
VIII. *An Account of a Catadioptrick Teleſcope, made by* John Hadley, *Eſq; F. R. S. With the Deſcription of a Machine contriv'd by him for the applying it to uſe.*

THE Inſtrument conſiſts of a metalline *Speculum*, about ſix Inches in Diameter. The *Radius* of the Sphere, on which its concave Surface was ground, is ten Feet, five Inches and one quarter, and conſequently its focal Length is 62 $\frac{5}{8}$ Inches. The Back has a hollow Screw made at its Centre, to receive the End of a Handle, which is ſcrew'd on, whenever the Metal is to be moved, in order to avoid ſullying its poliſh'd Surface by handling.

This Object-Metal A, *Pl.* II. *Fig.* 1. is placed in one End of an octangular Tube, B B, about ſix Feet long, and ſomething wider than what is ſufficient to receive the Metal, dyed black on the Inſide. About ſix or ſeven Inches in Length of the three uppermoſt Sides of the Tube C, (toward that End, at which the Metal is plac'd) are ſeparated from the reſt, and open with two Hinges, to make room for the Metal to be put in and taken out. The End of the Tube is cloſed by an octangular Piece of Board D, which has an opening *d*, about $\frac{2}{3}$ of an Inch broad, from the Top down to a little below the Centre, to give room for the beforemention'd Handle, when the Object-Metal is lifted into or out of the Tube; at other times it is cloſed with a ſliding Shutter. The

Metal

Metal is placed ſo, as to have its *Axis* coincide with that of the Tube, by the means of three ſmall Buttons fix'd to the Inſide of the Tube, having their hinder Ends all in the ſame Plane, to which this *Axis* is perpendicular. Two of theſe appear at *a a*, the third being at the middle of the Bottom of the Tube, is not ſeen. The foreſide of the Metal reſts againſt theſe Buttons in three Points of its Circumference, nearly equidiſtant from each other, and is held to them by three Screws, (one of which appears at *b*) which run through the octangular Board at the End of the Tube, and bear againſt the Back of the Metal, (in three Points, which directly anſwer thoſe three on the foreſide) with juſt ſo much Force, as is requiſite to keep it ſteady in its Place. They muſt not be ſcrew'd harder againſt the Metal for Fear of bending it, which (tho' it is half an Inch in Thickneſs) a very little Force is ſufficient to do. When the Inſtrument is not uſed, theſe Screws are looſen'd, and the Object-Metal is taken out and laid by, to prevent its tarniſhing.

The oval Plane is compos'd of a Plate of the ſame Metal with the great *Speculum*, about $\frac{1}{15}$ or $\frac{1}{16}$ of an Inch in Thickneſs, ſolder'd on the Back to another of Braſs. Its Breadth is ſomething leſs than half an Inch, and is in Proportion to its Length as 1 to $\sqrt{2}$. At one End of the Oval, the Braſs Plate projects a little beyond the other, and has a Screw cut through it in that Part, as likewiſe another directly againſt the Centre of the foreſide. The other End is cypher'd away on the Backſide, that it may intercept as few of the Rays, in their Paſſage towards the Object-Metal, as is poſſible. The two Screw-holes in the Back ſerve to fix this Oval A, *Fig.* 2. to a Braſs Arm, B, which is faſtened at the other End into a Slider E E. *Fig.* 1. and 2. This

Slider is of an equal Thickneſs with the Side of the Tube, and has a Groove, G G, *Fig.* 1. cut for it in that Side, parallel to the *Axis*, and long enough to give room for its Motion, to ſet the two *Specula* at the different Diſtances, which the ſeveral Eye-Glaſſes require. It reſts on the Inſide againſt two thin Ledges, faſtened within the Tube along the Sides of the Groove. On the Outſide it is kept in its Place by a ſliding Shutter, not expreſſed in the Figure. In the Middle it has a Cylindrick Cavity, D, *Fig.* 2. whoſe *Axis* is exactly perpendicular to its inner and outer Surfaces. Each of the Boxes, in which the Eye-Glaſſes are contained, is fitted to this Cavity. The beformention'd Braſs Arm is fix'd into the Inſide of this Slider, towards the End fartheſt from the Object-Metal; it riſes perpendicular for about two Inches, and is made flat, ſo as to turn one Edge to the Rays, which come from the Object. About *b*, it is bent forwards and flatted the other Way, ſo that when the Back of the oval Plane is held flat to it, by the two Screws *c c*, the Axis of the Cylindrick Cavity may fall on the Centre of its foreſide, inclin'd to its Surface in an Angle of ſomething leſs than fourty five Degrees. This Angle is brought to be exact by two very ſmall Screws, *i i*, whoſe Threads take hold in the flatted End of the Braſs Arm, and their Points bearing againſt the Back of the Oval, raiſe one End of it a little from the flat of the Arm. The *Specula* are ſet at their due Diſtance, by turning of a long Screw, C C, for which there is a Nut lodged in the Slider at *g*; the Screw is kept from moving backward or forward, when 'tis turned, by a Braſs Plate, F, which is to be fix'd to the flat End of the Side of the Tube, and taken off at Pleaſure. Each of the Eye-Glaſs Boxes, H, has a Screw on the outward End, to faſten to it a Bowl, or

Diſh, I, to receive the Ball of the Eye, and guard it from external Light.

On the Top of the Tube is fix'd, on two ſmall Pedeſtals, a common Dioptrick Teleſcope, H, *Fig.* 1. about eighteeen Inches long, its *Axis* parallel to that of the Tube; and having two Hairs plac'd in the common *Focus* of its Object and Eye-Glaſſes, croſſing one another in its *Axis*.

There are three convex Eye-Glaſſes belonging to the Inſtrument. The firſt, or ſhalloweſt, has its focal Diſtance of about $\frac{1}{3}$ of an Inch; the ſecond, of $\frac{3}{10}$; and the deepeſt, of $\frac{11}{40}$, or ſomething leſs. When the firſt of theſe is uſed with the Inſtrument, it magnifies about 188, or 190 times, in Diameter; with the ſecond, about 208; and with the third, 228 or 230. Each of theſe Glaſſes has placed, in that *Focus* neareſt the Oval, a Circle to determine the Part of the Object ſeen at one View; and in the other *Focus* toward the Eye, a Braſs Plate with a little Hole in the middle, to let no Light paſs to the Eye from the Inſide of the Tube, but what comes from the Oval. Beſides theſe three convex, there are two concave Eye-Glaſſes, with which it magnifies about 200 and 220 times; and alſo a Sett of three Convex, which turn it into a Day Teleſcope, magnifying about 125 times. The Aperture is limited by a Circle of Card, or Paſtboard, placed before the Object-Metal in the Tube. To vary the Aperture there are three of theſe Circles, and the Apertures allowed by them are five Inches and an half, five Inches, and four and an half, tho' for ſome Objects the whole Metal may be left open.

The Engine made uſe of to direct the Tube to any Object, conſiſts of a ſtrong Plank, FF, *Fig.* 1. and 3. about fourteen Inches wide, and two Feet and an half, or three Feet long, which ſerves as a Foundation for the

the whole. Near one End of this Plank is placed an upright fourſided Box, III, *Fig.* 1. and 3. about two Feet high, narrower at the Back next the End of the Plank than before: Its two Sides are mortiſed both into the Plank below, *a a*, *Fig.* 3. and into the Top of the Box above, *dd*; the back and fore Part are faſten'd to the Edges of the Sides with Wood-Screws. The Top has a circular Hole cut in it, ſomething above three Inches in Diameter, whoſe Centre is about three Inches diſtant from the outſide of the Back, and at an equal Diſtance from the two Sides. This Hole gives Paſſage to a turning Pillar B, in the Bottom of which there is fix'd an Iron Pivot *c*, to turn in a thick Braſs Plate lodged in the Plank, *b*. The upper End of the Pillar riſes about an Inch and an half above the Top of the Box, and is mortiſed into a ſtrong Head, K, *Fig.* 1. and 3. about eight Inches in Length, and four or five in Breadth and Thickneſs. This Head carries two Cheeks, L L, about thirteen or fourteen Inches in Height, their hinder Edges, towards the lower End, extending five Inches beyond the *Axis* of the Pillar backward. Along the Back of theſe Cheeks, at equal Diſtances above one another, there are Notches, tending obliquely downwards, and anſwering one another in each Cheek, to receive the Pivots of a crooked Iron *Axis*, C, *Fig.* 3. on which the Tube is plac'd. The Notches are made at different Heights, to keep the Eye-Glaſs at a proper Height for the Eye, in different Elevations of the Object above the Horizon. The Figure of the *Axis* anſwers that of the three under Sides of the Tube. The *Axis* of the Tube lies about two Inches and an half higher than the *Axis* of the Motion upon theſe Pivots, and the Centre of Gravity, when the Object-Metal is in, is about three Inches backwarder. To keep the Tube from ſlipping back, when its fore End is raiſed, it has two Buttons fixed to it, which reſt againſt the fore Part of the *Axis*.

To keep the Pillar from touching any of the Sides of the round Hole, in which it turns, a Cylindrick Sector, containing about 65° or 70°, and about an Inch in Height, is cut out on the back Part of the Pillar, near the upper End D. In the ſquare Angle of this Cavity is fix'd a thin Steel Plate *o o*, bent croſs the middle to the ſame Angle. The internal angular Edge, between the two Parts of this Plate, lies in the *Axis* of the Pillar, and turns upon the harden'd Edge of a Wedgelike Iron, *f*, whoſe Baſe, or Board Part, is faſten'd with two ſtrong Screws on the Top of the Box, directly behind the round Hole beforemention'd.

The upper Parts of the Cheeks are ſtrengthened by two Brackets, GG, leaving Room between them for the Bottom of the Tube to touch the upper Edge of the fore Part of the Head. The hinder Part of the Head is alſo hollow'd, in the Manner repreſented in the third Figure.

The Head on its fore Part carries a flat Arm, M, *Fig.* 1. about twenty ſeven Inches long, a little taper towards the farther End, where it is four Inches broad. This is ſtrengthened by a narrow Slip, glew'd edgewiſe along the middle underneath, O, and alſo by a Brace or Stay, N, reaching from the turning Pillar to within nine Inches of the End of the Arm. The Stay paſſes through a tranſverſe opening cut in the fore Part of the Box, P, which is long enough to allow room for a ſufficient Motion of the Pillar round its *Axis*.

On the other End of the Bottom Plank, tranſverſely to its Length, is erected a Board about twelve Inches wide, and twenty ſix or twenty ſeven high, Q, the Top of it reaching within an Inch and an half of the under Side of the Arm. This Board is held firm in its

Poſition by a Spur, R, part of its upper End on the outſide is pared off toward the Edges, to form it into the Segment of a Cylinder, whoſe *Axis* coincides with that of the Pillar. Its Uſe is to ſupport a Reſt, SS, on which the End of the flat Arm moves backward and forward. This Reſt being apply'd tranſverſely to the outer Part of the upright Board, where it is made Cylindrick, is bent into the ſame Figure, by the means of four Screw-Pins, two of which paſſing through each End of this, and of another Piece of the ſame Length, T, (but ſomething narrower) placed over againſt it on the inſide of the Board, by their Nuts, draw them together, ſo as to graſp the End of the upright Board between them; the upper Edge of the Reſt being firſt ſhot with a Plane very ſtrait and ſmooth. To render the Motion of the Arm along the Reſt ſmooth and eaſy, it has two Rollers lodged in a Box fix'd near to the End, on its underſide, V, to roll upon the Edge of the Reſt, when the End of the Arm is moved along it. One of the Rollers is placed near each Edge of the Arm, and their *Axes* lye in Lines paſſing through the *Axis* of the turning Pillar. The Reſt is kept up to them, with a proper Degree of Force, by two Screws, W W, which run in two Plugs, XX, faſtened on the Sides of the upright Board, and bear againſt the under Sides of two Pieces fix'd on the Inſide of the Reſt.

The Motion of the Tube is governed by two Braſs Pegs, Y and Z. The firſt of theſe, Y, is plac'd about 10 or 11 Inches from the End of the Arm, and has a Line wound round it, which paſſing under a ſmall Pulley, *f*, fix'd in a vertical Poſition near the End of the Arm, is faſtened to a Staple on the under ſide of the Tube *g*. This Line, by the turning of the Peg, brings the fore End of the Tube to its due Elevation, being acted againſt by the Exceſs of Weight in the hinder End

of

of the Tube, when the Metal is in it, which is equivalent to about two Pound at *g*, where the Line is faſtened. In great Elevations of the Object above the Horizon, the Line is not carried ſo far as the Point *g*; but is faſten'd a little above the Pulley, to a light ſquare Stick, *h*, having at one End a Hook, by which it takes hold of the Staple *g*. This is done, that the Springyneſs of the Line may not continue a vibrating Motion in the Tube, (when any thing happens to ſhake the Inſtrument) and make the Object appear to tremble. The lower Part of the Stick reſts againſt the end of the Arm, and by its ſlight Friction contributes to the ſame Effect.

The other Peg, *z*, is ſo plac'd, that it may be conveniently reached by one Hand of the Obſerver, while the other is employed about the Peg Y: It regulates the Horizontal Motion of the Tube, by means of a Line, which being wound about the Peg at one End, paſſes by another ſmall Pulley placed cloſe by the Side of the aforementioned one in an Horizontal Poſture (not to be ſeen in the Figure) and is hung on a Pin driven into the little Head K. It is acted againſt by two Springs, *m* and *n* *Fig.* 3. placed in the Box, I I I, one on each Side of the turning Pillar; that on the right Hand, *m*, draws the right Side of the Pillar forward, by a very ſtrong Line, which being faſtened to the Head of the Spring, paſſes round the back Part of the Pillar to a Pin, at P, by which it is ſtrain'd to its due Strength. The Spring on the Left Hand *n*, draws the Left Side of the Pillar backwards in the ſame manner. Theſe Pins are plac'd on the Pillar a little higher than the Tops of the Springs, that being drawn a little downwards, as well as turn'd round its *Axis*, the Pivot in its Bottom may not be raiſed out of the Hole in the Braſs Plate, when the Reſt bears hard againſt the Rollers at the End of the Arm. Each of theſe Springs draws with a Force equal to about

18 or 20 Pounds Weight, when the End of the Arm is carried cloſe to the ſmall Head *k*, Fig. 1. and conſequently (the Semidiameter of the Pillar being an Inch and Half, and the Diſtance of that Head from the *Axis* about 28 or 29 Inches) the End of the Arm will be carried by the united Forces of both the Springs, towards the other End of the Reſt, with a Force equivalent to the Weight of about two Pounds. Each of the Pegs, Y and Z, turns in a Hole made in a Piece of Wood *l*, faſtned to the under Side of the Arm; and the Pieces being ſlit with a Saw from one End through the Hole, and about half an Inch beyond it, the ſeparated Parts are drawn together by a Skrew *m*, till the End of the Peg is griped between them, with a due Degree of Force. By theſe Pegs, with the help of the Teleſcope H, the Tube is eaſily directed to any Object, and made to accompany a Celeſtial one in its Diurnal Motion, while the End of the Arm moves the whole Length of the reſt.

If it be deſired, that when the Object is found, the turning of one Peg ſhould carry the Tube along with the Motion of the Heavens, ſo as to keep the Object always in ſight; this may eaſily be effected in various Manners.

The concave Surface of the Object-Metal has many little Spots in it, which could not be brought to take a Poliſh. In one, or two Places, the Metal itſelf ſeems to have ſome ſmall Parts, ſomething harder or ſofter than the reſt, occaſioning an irregularity in the Figure of the Metal about them. But theſe Parts being ſmall, in Proportion to the whole, do not ſeem conſiderably to affect the Diſtinctneſs of the Appearance.

The open Air has commonly an undulating Motion in its Parts, eſpecially in the day time, which occaſions the Rays of Light to deflect a little from the ſtrait Lines, in which they ought to move, in order to render the

Species perfectly diſtinct. The Effect of this, though inſenſible to the naked Eye, or even through a ſmall Teleſcope, becomes conſiderable, when the Object is very much magnified. The Inſtrument, when try'd at an Object encloſed, ſo as to ſecure it from this Inconvenience, ſeems to bear an Aperture of five Inches and an half, with the deepeſt of the forementioned Eye-Glaſſes, as well as the common Teleſcopes do the uſual Charge and Aperture given to them, except that in theſe the Objects appear a little brighter.

Fig. 1. Repreſents the Inſtrument placed on the Machine, in order to be apply'd to Uſe.
Fig. 2. Repreſents the Inſide of the Slider, with the reſt of the *Apparatus* belonging to the oval Plane and Eye-Glaſs.
Fig. 3. Repreſents the hinder Part of the Machine, the Back, and one ſide of the Box, being taken away, to ſhew the turning Pillar and Springs on the Inſide.
Fig. 4. Repreſents *Saturn*, as it appear'd in *June*, 1720, by this Teleſcope.

FIG. I.

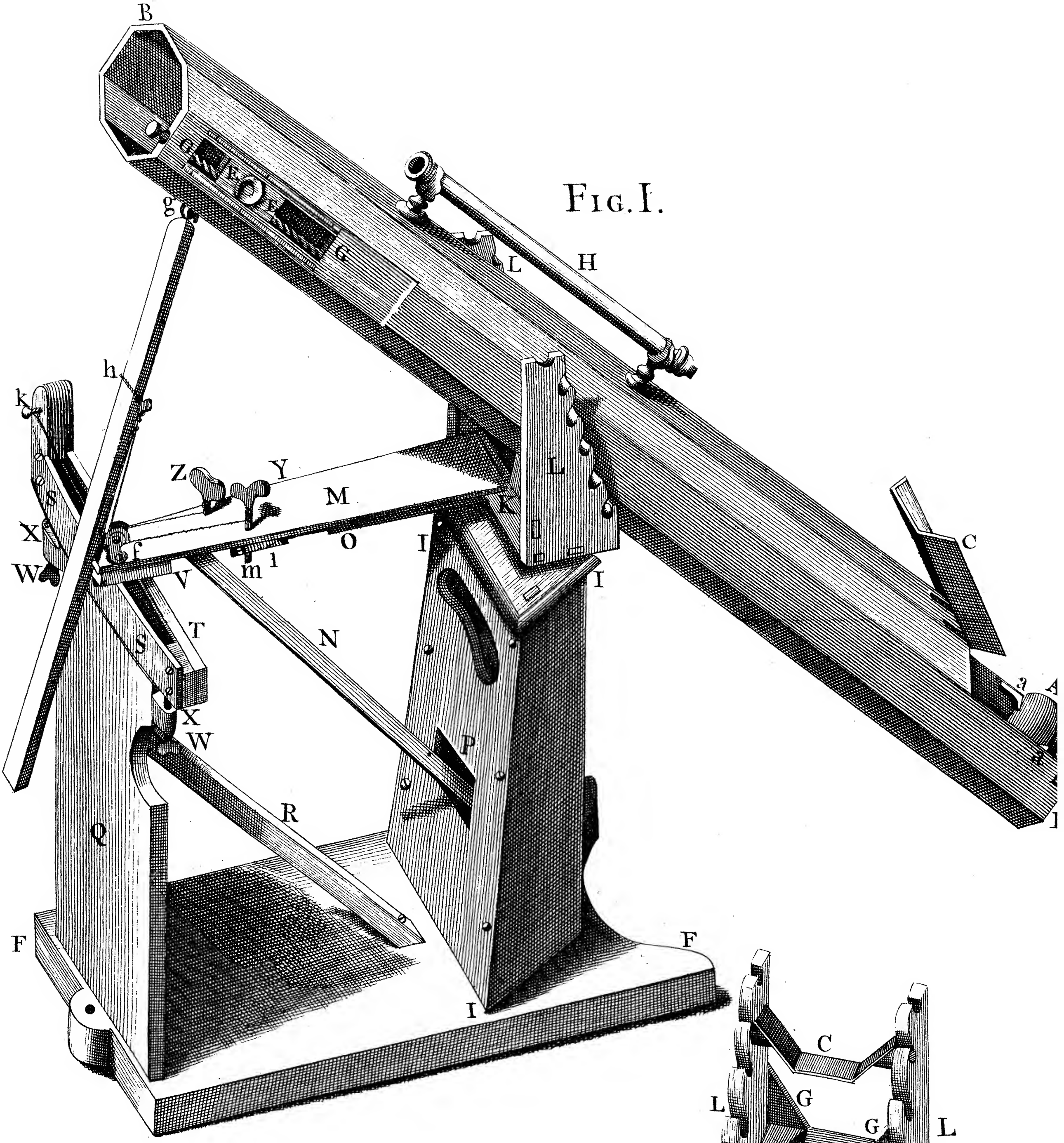


FIG. II.

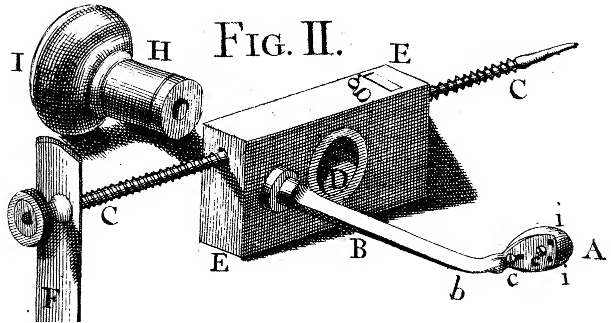
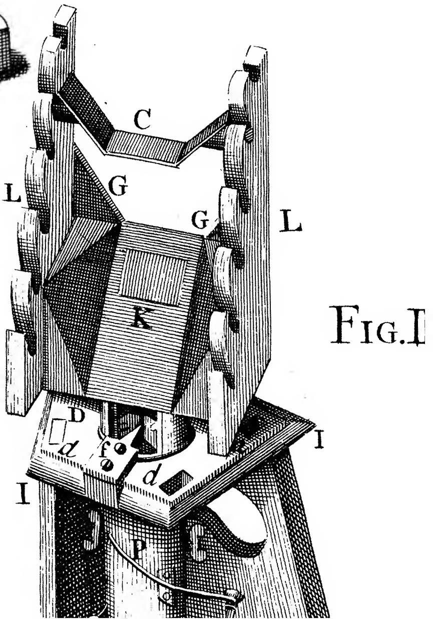


FIG. I



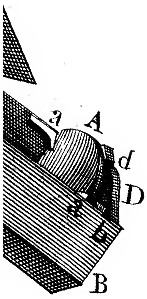
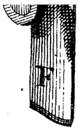


Fig.III.



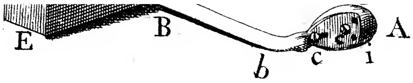
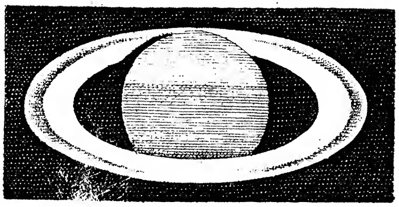
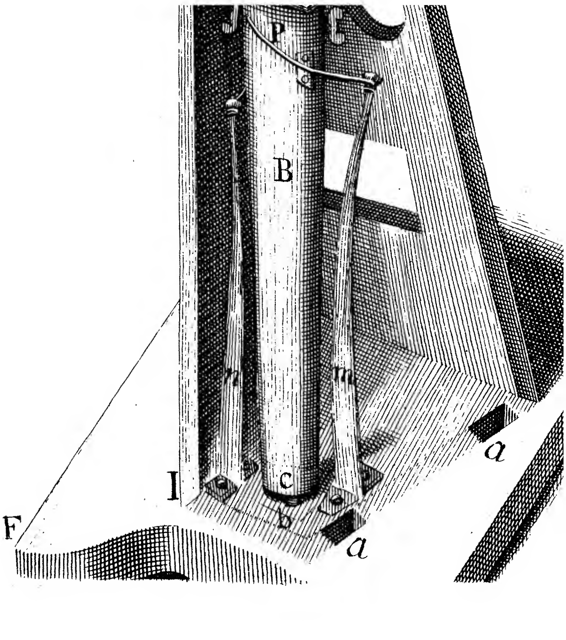


FIG. IV.





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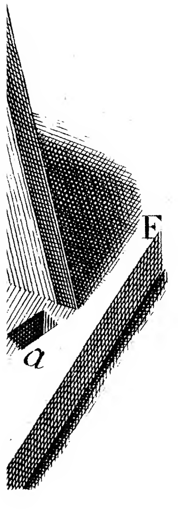
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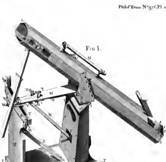
Fig I.

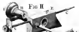
Fig II

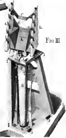
Fig III

Fig IV

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